

# *Salenia trisuronalis* sp. nov. (Echinoidea) from the Eocene (London Clay) of Essex, and notes on its phylogeny

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## Synopsis

The new species *Salenia trisuronalis*, with three suranal plates, is described from the English Eocene, and its phylogenetic position with respect to other echinoids discussed in the light of Hennigian methodology. The presence of suranal plates tessellated into the apical disc is seen as likely to be a synapomorphy with irregular echinoids, and suggests they are probably the sister group to the Salenioida.

## Introduction

Salenioids, after their great expansion in the Cretaceous, are uncommon subsequently, and in the Eocene are very rare indeed. *Salenia trisuronalis* sp. nov. is the first record of a *Salenia* from the British Cainozoic. Two continental species from the Eocene – *S. pellati* from La Gourèpe near Biarritz, and *S. garciae* from Callosa, Alicante, have certain similarities, but neither has more than one suranal plate.

*Salenia trisuronalis* is now described, and an attempt is made to assign it to its phylogenetic position with respect to other echinoids.

## Systematic description

Superorder ECHINACEA Claus, 1876  
Order SALENIODA Delage & Hérouard, 1903  
Family SALENIIDAE L. Agassiz, 1838  
Subfamily SALENIINAE L. Agassiz, 1838  
Genus *SALENIA* Gray, 1835  
*Salenia trisuronalis* sp. nov.  
Figs 1–4

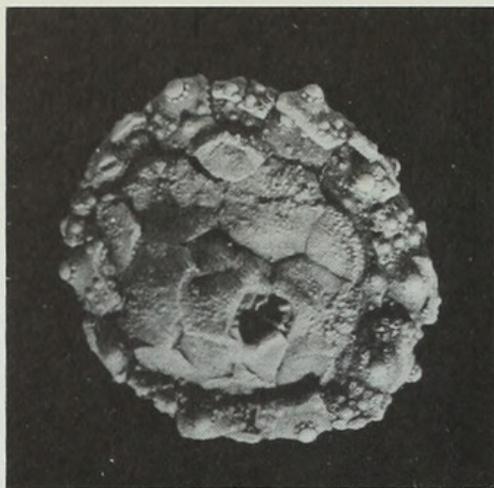
DIAGNOSIS. The species is characterized by having three suranal plates.

MATERIAL (Figs 1, 2). The unique holotype is well preserved, slightly crushed and flattened in the ambital plane. One spine is preserved, an interambulacral, on the oral surface. The specimen is in the Palaeontology Department of the British Museum (Natural History), number E76505. It is from the London Clay (Lower Eocene) of Walton-on-the-Naze, Essex, England and was collected by Mr William George.

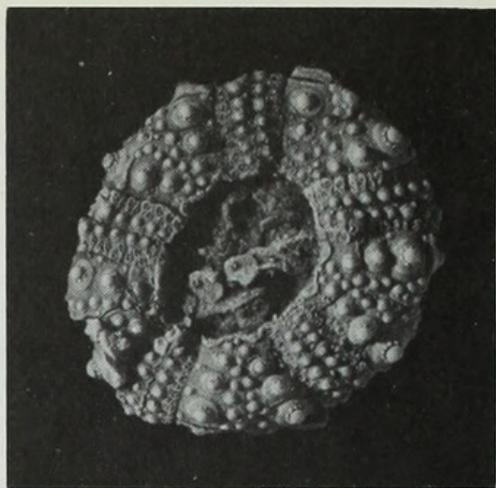
SHAPE. The test is small, circular in outline at the ambitus, with a maximum diameter of 8.25 mm, minimum 7.5 mm; the exact measurement is uncertain because of the damaged state of the test. The oral surface is flat; the apical surface is irregular owing to plate displacement.

APICAL SYSTEM. This is dicyclic with three suranal plates. (Notation follows Lovén 1874).

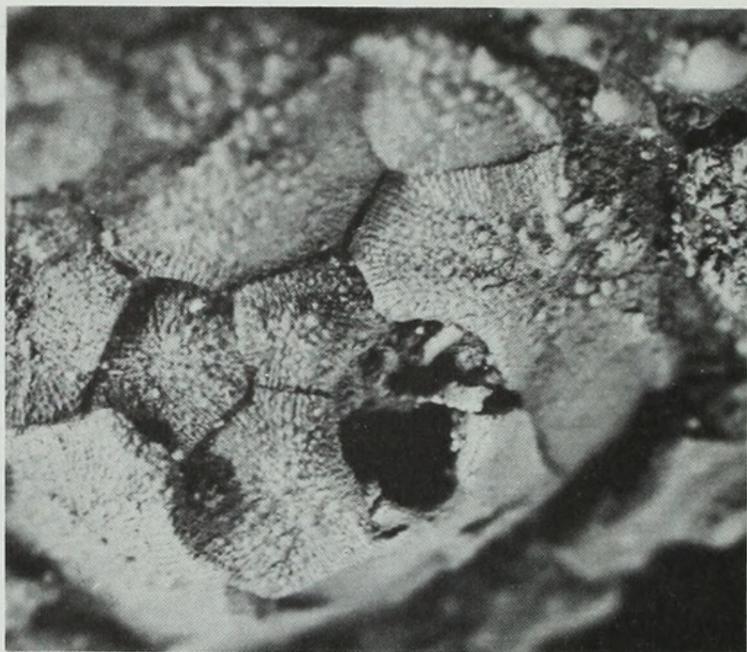
*Ocular Plates.* The inner sutures are rounded, and the outer suture is a single arc. The ornament consists of fine ridges arranged approximately perpendicular to each inner suture. The centre of



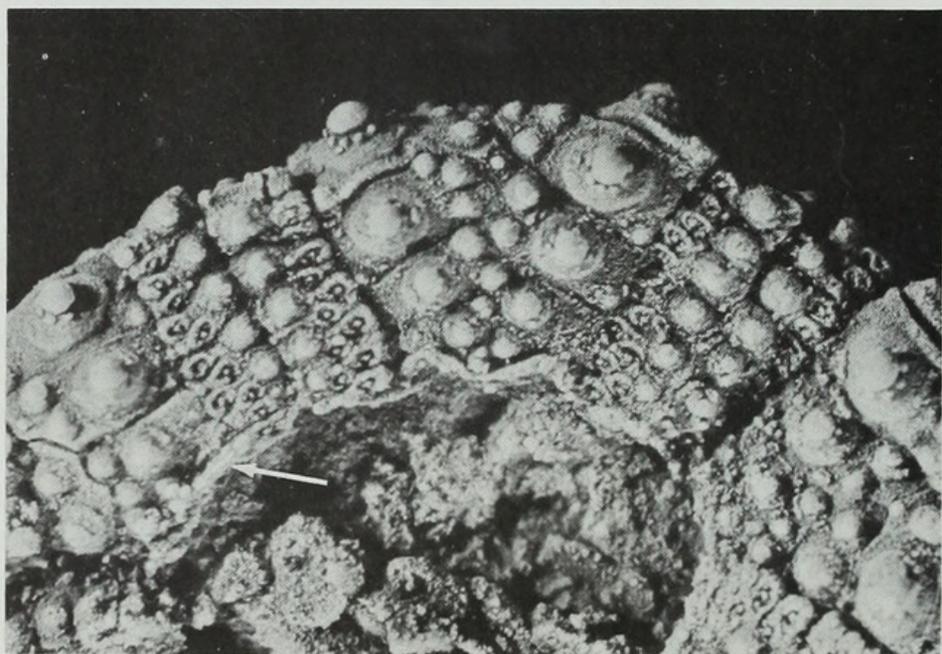
1



2



3



4

**Figs 1–4** *Salenia trisuranalis* sp. nov. **Holotype**. Fig. 1, adapical view,  $\times 5$ . Fig. 2, adoral view,  $\times 5$ . Fig. 3, close-up of periproct to show the three suranal plates,  $\times 15$ . Ornament of fine ridges and granules, found over the whole of the apical system, can be seen on the suranal plates. Fig. 4, close-up of ambulacra II and III and interambulacrum 2,  $\times 13$ . A small spine is visible, attached to interambulacrum 1, innermost margin (arrowed).

each ocular plate has granular ornament, and the outer edge has a knobby ridge the whole of its length. Each ocular plate has a slightly raised, broad v-shaped notch for the ocular tentacle, in the centre of the ridge.

*Genital Plates.* Genital plate 1 is polygonal, with a shallow notch which is ornamented by fine ridges and which forms part of the slightly raised rim around the periproct. The plate ornament consists of fine ridges approximately perpendicular to the margins, a granular central ornament and a knobby ridge, concave to the outer margin and in continuation with the ridges on ocular plates I and II. External to this ridge more granules ornament the surface.

Genital plate 2 is octagonal, with ornament similar to that of genital plate 1, comprising fine ridges perpendicular to the inner five margins; the central part of the plate is divided into an inner portion with an irregular surface, and radiating from this an outer portion with granular ornament. There is no continuation of the knobby ridge from adjacent oculars. However, the granular ornament ceases where the ridges of the oculars meet the plate margin. Connecting the outer two sutures is a convex strip of unornamented plate. There is no external evidence of the madreporic pores.

Genital plate 3 is heptagonal, with a similar ornament of fine ridges around the inner five margins. The centre has granular ornament which radiates towards the outer two sutures and, as in genital plate 2, has an unornamented arcuate strip.

Genital plate 4 is displaced and therefore the boundary is not wholly visible. The plate is polygonal, with ornament like that of genital plates 2 and 3.

Genital plate 5 is polygonal but the outer margin is not visible. A deep notch forms part of the rim around the periproct. Ornament is of fine ridges along the margins as on the other genital plates, but the centre has granular ornament and a knobby ridge meeting the adjacent oculars, as on genital plate 1.

*Suranal Plates* (Fig. 3; for discussion see Duncan & Sladen 1887). There are three suranal plates, two along the axis connecting ambulacrum III with interambulacrum 5, and one to the right of this axis, towards ocular plate II. One suranal plate, towards genital plate 5, is larger than the other two and has five straight sides with ornament of fine ridges, and one curved side that makes up part of the periproct rim. The centre of this suranal plate has fine granular ornament, with fine ridges converging into this ornament. The second suranal plate has four straight sides and one smoothly curved side which, again, forms part of the rim of the periproct. The ornament is similar to that of the larger suranal plate. The third suranal plate is partly obscured by genital plate 4 which has overridden it in crushing; however it is pentagonal, with ornament like that of the other two suranal plates.

*Periproct.* This is bounded by genital plates 1 and 5, and by two suranal plates. The outline is smooth and kidney-shaped, and lies right of the anteroposterior axis (ambulacrum III – interambulacrum 5) and between ocular plate I and two of the suranal plates. The ornament consists of short fine ridges perpendicular to the edges.

*Notes on the ornament.* The whole of the apical system is ornamented by granules and fine ridges, and in addition by larger knobby ridges. The fine ridges are continuous from one plate to those adjacent. The genital plates are not perforated by genital pores, suggesting that the individual may be immature.

*AMBULACRA* (Fig. 4). These are straight and wide. At the peristome they are the same width as the interambulacrals. At the ambitus they are half as wide as the interambulacrals, while at the apical system they are slightly less than half as wide as the interambulacrals.

The plating is difficult to determine except where displaced along the plate boundaries by crushing, but it appears to be bigeminate, with pore pairs oblique.

The pore pairs are surrounded by a smooth deep wall, higher on the aboral side and incomplete on the adoral side. The pores are separated by a single granule situated only slightly towards the adradial suture.

There are 18 primary ambulacral tubercles in each ambulacrum. Each tubercle is large, smooth and in contact with the perradial suture and also close to the pore pairs, with each tubercle

covering at least half the width of the plate. The smallest primary tubercles are the first two or three pairs nearest to the peristome, and the largest are developed at the ambitus. Small inner tubercles are also present.

**INTERAMBULACRA** (Fig. 4). These widen rapidly from the peristome. The interambulacra are twice as wide at the ambitus as they are at the peristome, and have ten primary tubercles, with one on each plate. The tubercles are situated close to the adradial sutures. In the interradial position there are numerous smaller tubercles, two per larger primary tubercle. Very occasional granules are also present. Plate boundaries are difficult to determine except where dislocated.

The primary tubercles are non-perforate, and have 8–11 crenulations according to size. All smaller tubercles are non-crenulate.

The bosses of the primary tubercles are convex, rising from a rounded basal terrace. The mamelons have slightly undercut necks. Smaller tubercles have convex bosses arising from shallow, rounded basal terraces, and have very short, slightly undercut necks.

**PERISTOME.** This is large, round, about 4 mm in diameter, and is slightly distorted (*post mortem*). Remains of the raised rim of the gill slits can be seen on ambulacra III and IV and on interambulacra 1, 2, 4 and 5, the others having been broken away.

**SPINE** (Fig. 4). One spine is present on interambulacrum 1, near the peristome. It is about 0.9 mm long and is not in life position. It is straight, flattened and ornamented by rows of thorns. It tapers proximally into a short neck and ends in a slightly expanded base.

**COMPARISON** with other species. The specimen, which was first mentioned by George & Vincent (1977), was initially identified as *Salenia* cf. *pellati* on the basis of Cotteau's figures (1860, 1892). However, closer examination reveals some differences, the chief of which is the presence of three suranal plates in *S. trisuronalis* and only one in *S. pellati*. The ornament on the ocular plates of *S. trisuronalis* is like that on the genital plates, but on *S. pellati* it is different – the ribbing is coarser on the ocular plates, and these are perforate. The apical disc covers about the same area in both species. The peristome appears larger in *S. pellati* where it is about the same diameter as the apical disc, whereas in *S. trisuronalis* it is smaller than the apical disc.

Ambulacra are similar to those of *S. pellati* in width, size and numbers of primary tubercles. In *S. pellati* pore pairs open '... at the base of a small granular swelling ...', while in *S. trisuronalis* they are surrounded by a deep wall. Interambulacra are different from those of *S. pellati* in that *S. trisuronalis* has more primary tubercles, although these are similar to that species in structure and numbers of crenulations. *S. garciae* Cotteau (1890) differs slightly in detail, although the type specimen was incomplete, so that the apical disc was not described. The interambulacra of *S. garciae* have many more granules around the primary tubercles and the ambulacra are longer, narrower and have more tubercles. The pore pairs of *S. garciae* appear to have little ornament around them.

## Discussion

The Salenioids are divided in the Treatise of Invertebrate Paleontology (Fell & Pawson 1966) into two families – the Acrosaleniidae and the Saleniidae. The Saleniidae are in turn divided into the Saleniinae and the Hyposaleniinae. In the light of Hennigian methodology (Hennig 1966, 1969) it is interesting to consider the phylogenetic relationships of these and other groups.

All known Salenioids are distinguished from other echinoids, except primitive irregular forms, by having one or more suranal plates tessellated into a large apical disc. Many echinoids have an obvious suranal plate in the imago, but usually this later becomes lost amongst the other periproctal plates (see, for example, Gordon 1926, on *Psammechinus miliaris*). The presence of suranal plates tessellated into the apical disc is an advanced character with respect to other echinoids and could be a synapomorphy of Salenioids and irregular echinoids. It suggests that Salenioids may be the sister group of the irregular echinoids (see Jesionek-Szymańska 1968). Its retention in the Salenioids is a pedomorphic character, but its tessellation into the apical disc is not pedomorphic.

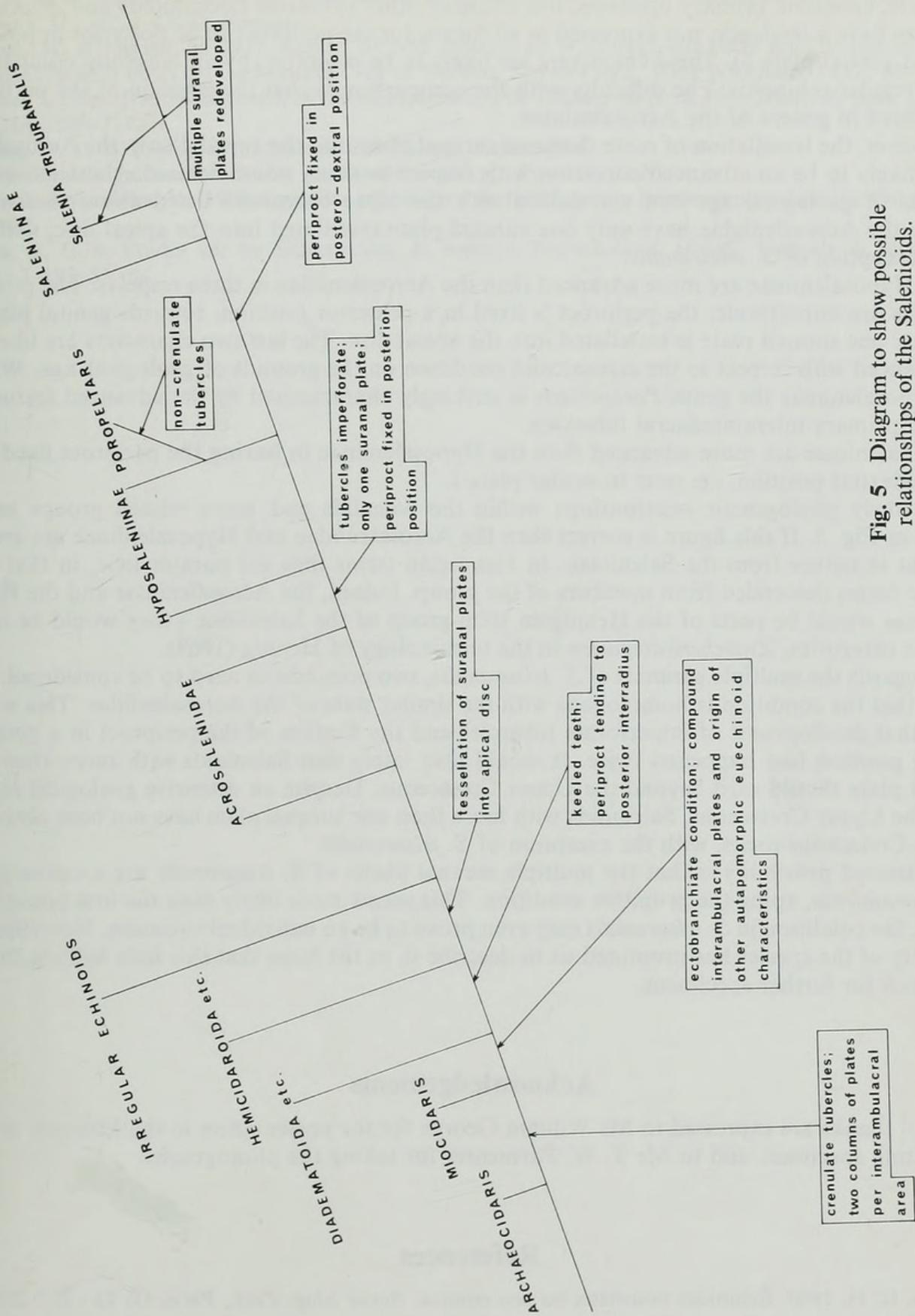


Fig. 5 Diagram to show possible relationships of the Salenioids.

The Acrosaleniiidae probably include the most primitive members of the Salenioids. The reasons for this belief are three. They are geologically early compared with other Salenioids, they have perforate, crenulate primary tubercles, like those of other primitive Euechinoids and *Miocidaris* and they have a tendency, not expressed in all forms, for the periproct to be posterior in position (toward genital plate 5). These characters are likely to be primitive, by an outgroup comparison with irregular echinoids. The difficulty with the comparison is that the position of the periproct is not fixed in genera of the Acrosaleniiidae.

However, the tessellation of more than one suranal plate into the apical disc in the Acrosaleniiidae is likely to be an advanced condition with respect to many non-Saleniod echinoids, on the grounds of geological age and correlation with the three characters listed above. Salenioids outside the Acrosaleniiidae have only one suranal plate tessellated into the apical disc, with the single exception of *S. trisuronalis*.

The Hyposaleniiinae are more advanced than the Acrosaleniiidae in three respects. The primary tubercles are imperforate, the periproct is fixed in a posterior position, towards genital plate 5, and only one suranal plate is tessellated into the apical disc. The last two characters are likely to be advanced with respect to the acrosaleniid condition on the grounds of geological age. Within the Hyposaleniiinae the genus *Poropeltaris* is strikingly characterized by the advanced feature of smooth primary interambulacral tubercles.

The Saleniinae are more advanced than the Hyposaleniiinae in having the periproct fixed in a posterodextral position, i.e. near to ocular plate I.

The likely phylogenetic relationships within the Saleniids and some related groups are as shown in Fig. 5. If this figure is correct then the Acrosaleniiidae and Hyposaleniiinae are groups different in nature from the Saleniinae. In Hennigian terms they are paraphyletic, in that they exclude forms descended from members of the group. Indeed, the Acrosaleniiidae and the Hyposaleniiinae would be parts of the Hennigian stem-group of the Saleniinae – they would be intermediate categories, *Zwischenkategorien* in the terminology of Hennig (1969).

As regards the multiple suranals of *S. trisuronalis*, two possibilities need to be considered. The first is that the condition is homologous with the similar state of the Acrosaleniiidae. This would imply that development of imperforate tubercles and the fixation of the periproct in a posterodextral position had happened twice. It would also imply that Salenioids with more than one suranal plate should exist beyond the Upper Cretaceous. Despite an extensive geological record up to the Upper Cretaceous, Salenioids with more than one suranal plate have not been observed in post-Cretaceous rocks, with the exception of *S. trisuronalis*.

The second possibility is that the multiple suranal plates of *S. trisuronalis* are a convergence with *Acrosalenia*, aping the primitive condition. This seems more likely than the first possibility. Indeed, the condition in *S. trisuronalis* may even prove to be an individual variation. Nevertheless, the rarity of the species has prompted us to describe it, in the hope that this note will encourage the search for further specimens.

### Acknowledgements

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